Cairo Univ. Afr. Stud. Rev. .17 (1995): P 17-34

Functional groups of soil mesofauna populations as components of ecosystem maturity in Wadi Allaqi area.

By

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ABSTRACT

Data on populations of soil mesofauna from Wadi Allaqi, Wadi Quleib, and Dihmit farm, southeastern desert of Egypt, during the period between December 1989 and February 1991, were grouped into 20 species. The three sites selected represent different degrees of man induced ecological disturbance, ranging from a grazing ecosystem in Wadi Quleib which was never inundated by water, to several years of inundation by water of Aswan High Dam Lake with small scale farming in Wadi Allaqi, to a completely barren and rainless flat sandstone desert reclaimed since 1987 for cultivation using underground water at Dibmit. Maturity index based on populations of soil mesofauna as well as the functional groups (herbivores, detritivores' and carnivores), separately, was determined. Maturity index of the total soil mesofauna populations shows that Dihmit farm is still young and immature and Wadi Quleib is to be considered as a mature ecosystem, whereas Wadi Allaqi is intermediate. Concerning the functional groups, only detritivores follow the same pattern while in the case of herbivores the order is Allaqi minimum (least mature) and Quleib maximum. In the case of carnivores Quleib is minimum and Dibmit is maximum, showing that carnivores (natural enemies of pests) are disfavoured with increasing disturbance. Use of the maturity index is therefore recommended as a tool of understanding the intensity of disturbance in ecosystems of unknown history. Its use for functional groups will help to understand the status of natural enemies and to correct their dynamic imbalance in order to increase their efficiency.

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INTRODUCTION

Human intervention in more or less natural ecosystems, such as grazing processes and agricultural practices with the application of either fertilizers or pesticides, results in disturbance and subsequent new succession or recovery of the soil ecosystem (Ettema and Bongers 1993) which is reflected in the composition and community structure of soil mesofauna assemblages. Soil mesofauna assemblages are classified into three major trophic (functional) groups: detritivores (useful in soil fertility), herbivores (potential pests), and carnivores (potential natural enemies for biological control). In mature and stable ecosystems, these three trophic groups are in equilibrium. On the other hand, in young and immature ecosystems as well as in ecosystems subjected to human intervention, a series of disequilibria will occur in proportions of these three trophic groups which may lead to unpredictable pest outbreaks.

Based on their life strategy, soil mesofauna can be scaled from colonizer (r-strategists) to persisters (K-strategists). Weighted means of these proportions gives an indication of the stability of the ecosystem from which the sample originates (Bongers 1990). In his study, Bongers (1990) found that Nematodes appear to be appropriate organisms for the study of colonization and ecosystem development in newly reclaimed lands. Soil mesofauna assemblages as a whole, may be appropriate in this occasion.

The aim of the present paper is to investigate the degree of maturity of three sites in the south eastern desert of Egypt having a gradient of the intensity of human interventions. Two of these sites, Wadi Quleib and Wadi Allaqi, are grazing sites. The first one was not inundated while the second undergoes periodic inundation by waters of Lake Nasser. The third site, Dihmit farm, is a newly reclaimed desert area since 1987.

Material and Methods

A) The Study Area:

Three sites; Wadi Allaqi (Dickinson *et al.* 1994), Wadi Quleib, and Dihmit farm; were selected. Wadi Allaqi/Wadi Quleib area is located in the Eastern Desert of Egypt (33°-43° E; 22°-23° N) & 180 km south of Aswan. Wadi Allaqi extends as far as the Sudan border and is fed by a number of tributaries. Wadi Quleib is a principal tributary of Wadi Allaqi. The most important plant species are *Tamarix nilotica, Glinus lotoides, Pulicaria crispa* in downstream in Wadi Allaqi *and Acacia raddiana and Aerva javanica* in downstream in Wadi Quleib (Springuel *et al.* 1989). The area of Dihmit farm lies 60 km southeast of Aswan (Map 1). The area is a completely barren and rainless flat sandstone desert. The land was reclaimed since 1987 and used for cultivation and irrigated by underground water. Its area is about 5-7 acres and used for growing carcade *(Hibiscus sabdariffa), Casuarina* sp., and *Lawsonia inermis.*

The three sites are of the hyperarid province of Egypt and receive virtually no rainfall (Ayyad and Ghabbour 1986). The climate is extremely harsh. Winter is comparatively mild but maximum temperature exceeds 40°C from March to October.

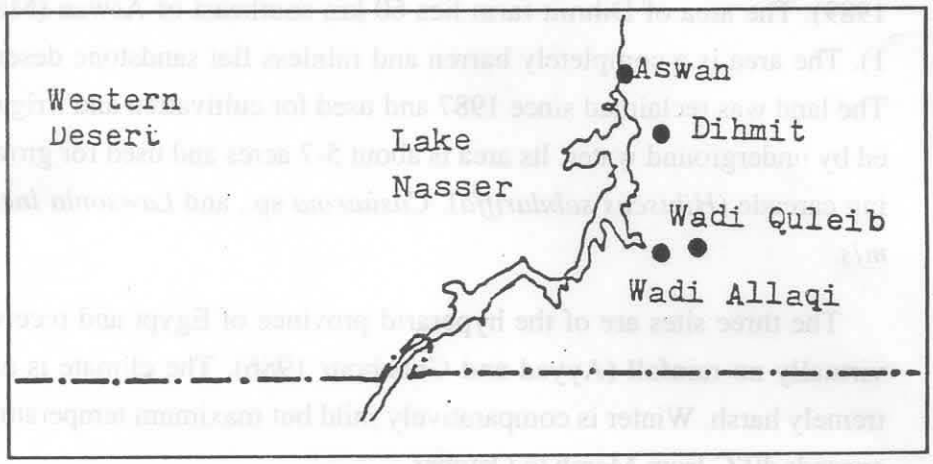
B) Method of Sampling Soil Fauna:

Soil mesofauna (larger than 1 mm) were collected by means of the pitfall trap method as described by Southwood (1978) and Slingsby and Cook (1986). Population density of soil fauna considered in this case is rather "activity density" in reality (Kromp 1990; Mikhail 1993) and expressed as individuals per pitfall trap.

Samples of soil fauna were collected monthly from each of Wadi Allaqi' Wadi Quleib, and Dihmit farm during the period between December 1989 and February 1991, with some gaps in-between.

C) Treatment of Data:

The maturity index (MI) as suggested by Bongers (1990) was used for each of Wadi Allaqi, Wadi Quleib, and Dihmit farm. This is an interesting approach to soil quality assessment, ecological typology, and biomonitoring (Bernard 1992). Species and/or families of soil fauna are ranked on a colonizer/persister (c-p) scale. The sum of c-p multiplied by the frequency for each taxon divided by the number of taxa present yields a statistic termed maturity index, a measure of ecological disturbance (Bongers 1990) and ecological succession (Ettema and Bongers 1993).



Map (1) Location map of the study area

RESULTS

Table (1) lists soil mesofauna species recorded in each of the three sites; Wadi Quleib, Wadi Allaqi, and Dihmit farm; of the present study, classified into the three major trophic (functional) groups: detritivores, herbivores, and carnivores, with the corresponding colonizer-persister value for each species. The three sites are arranged in descending order: Wadi Quleib, Wadi Allaqi, and Dihmit farm, according to the degree of human intervention. Maximum human intervention is in Dihmit farm

and the minimum is in Wadi Quleib, whereas Wadi Allaqi is intermediate. Number of species of each of the total soil mesofauna, detritivores, herbivores, and carnivores is shown in Fig. (1). It is noticed that Dihmit farm has the lowest number of species of either the total soil mesofauna or each of the three functional groups separately. Each of Wadi Quleib and Wadi Allaqi, has an equal number of detritivores and herbivores species. On the other hand, Wadi Allaqi has a greater number of species of each of the total soil mesofauna and carnivores, than Wadi Quleib.

Fig. (2) shows number of species of soil mesofauna at the three sites of the present study in relation to the colonizer-persister scale. The persister species are higher in each of Wadi Quleib and Wadi Allaqi, in relation to the total number of species recorded in these two sites. In Dihmit farm, the number of colonizer species is higher in relation to the total number of species recorded in this site (30%).

Simpson index of diversity at the three sites of the present study in relation to colonizer-persister scale is shown in Fig. (3). Generally, the persister species have higher diversity indices in the three sites and the colonizer species have the lowest. The lowest diversity of colonizer species is in Dihmit farm and is higher in each of Wadi Quleib and Wadi Allaqi. The colonizer-persister scale 2 has zero diversity, since there are no species corresponding to this value in each of Wadi Quleib and Dihmit farm and only one species in Wadi Allaqi (Fig. 2).

Calculation of maturity index (MI) for each of the three sites based on the total soil mesofauna population as well as the three functional groups separately (Fig. 4), shows that high values were obtained in Wadi Quleib for each of total soil mesofauna, detritivores, and herbivores, and a low value in the case of carnivores. Wadi Allaqi has an intermediate value in the case each of total soil mesofauna, detritivores, and carnivores, and a low value in the case of herbivores. Dihmit farm

has low values in the case of each of total soil mesofauna and herbivores, an intermediate value in the case of herbivores and a high value in the case of carnivores.

Fig. (5) shows results of the cumulative number of species of total soil mesofauna as well as detritivores, herbivores, and carnivores, recorded at the three sites of the present study during the period of sampling, in relation to the cumulative number of samples, showing a "J" type of curve in the case of Dihmit farm, meaning that the number of species recorded in this site is not yet exhaustive, except perhaps for herbivores. On the other hand, in each of Wadi Quleib and Wadi Allaqi, the number of species collected seems to be exhaustive.

Fig. (6) shows evolution of maturity index with time, based on soil mesofauna populations in each of the three sites of the present study. Wadi Quleib is represented by a straight line indicating stability and Wadi Allaqi is represented by a slightly curved line indicating moderate stability, whereas Dihmit farm is represented by an ascending curve, indicating a trend towards stablity from an unstable condition.

Table (1) List of species of soil mesofauna collected from Wadi Quleib (Q), Wadi Allaqi (A), and Dihmit farm (D) with the corresponding colonizer persister (c-p) scale.

Taxa	Q	A	D	c-p
Detritivores				
Thysanura	+	+		1
Formicidae				
Camponotus sp.			+	1
Buprestidae				
Julodis fembriata	+	+		3
Tenebrionidae				
Adesmia bicarinata	+	+		4
Mesostena angulatus	+	+	+	4
Pimelia subquadrata	+	+		4
Scelosodis castaneus	+	+	+	4
Trachyderma philistina	+	+		4
Herbivores				
Gryllidae				
Gryllus burdigalensis	+	+	+	5
Lepidoptera				
Coleophora euryaula	+	+	+	1
Crambus sp.	+	+		1
Formicidae				
Messor sp.	+	+	+	3
Monomorium sp.	+	+	+	1
Chrysomelidae				
Diorhabda elongata sublineata	+	+	+	4
Carnivores				
Mantidae		+		4
Dermaptera				
Forficula sp.			+	3
Pompilidae		+		2
scorpion	+	+		5
Araneida				
Araneus sp.	+	+	+	5
Paradosa sp.	+	+		5

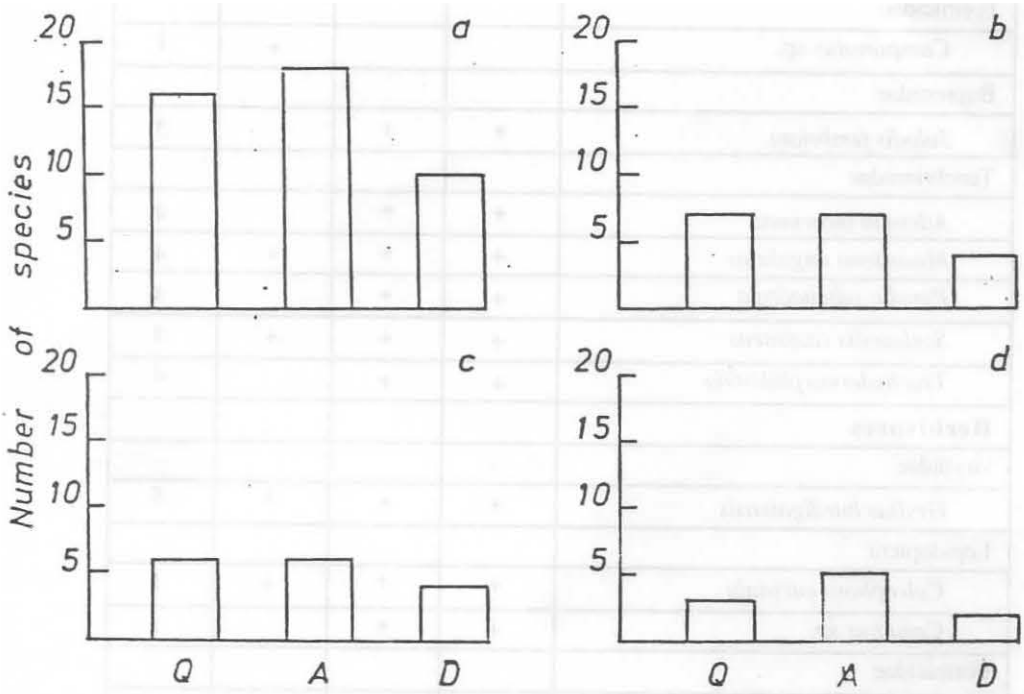


Fig. (1) Number of species of each of total soil mesofauna (a) detritivores (b), herbivores (c), and carnivores (d) collected in each of Wadi Quleib (Q), Wadi Allaqi (A), and Dihmit farm (D).

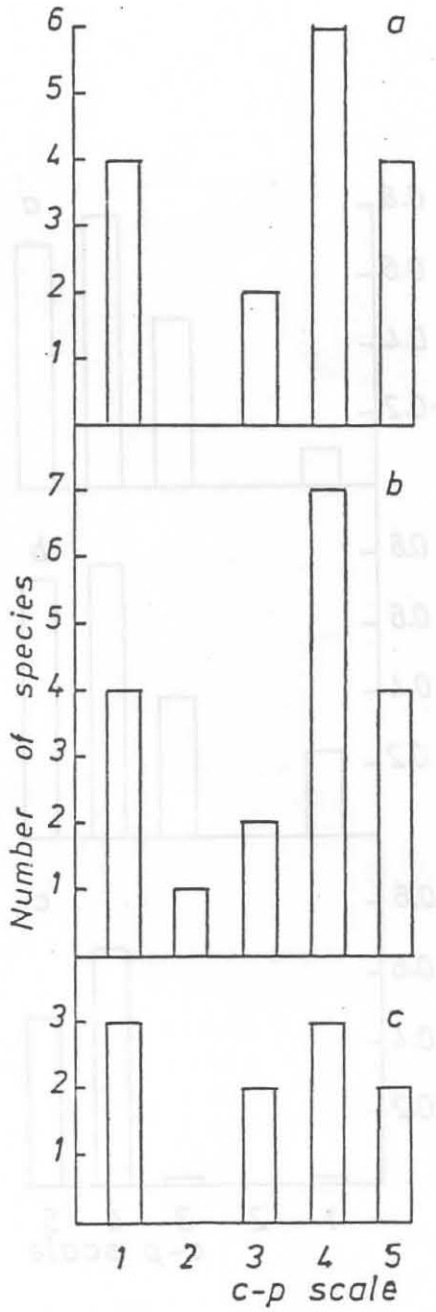


Fig. (2) Number of species of soil mesofauna at Wadi Quleib (a), Wadi Allaqi (b), and Dihmit farm (c) in relation to the colonizer-persister (c-p) scale.

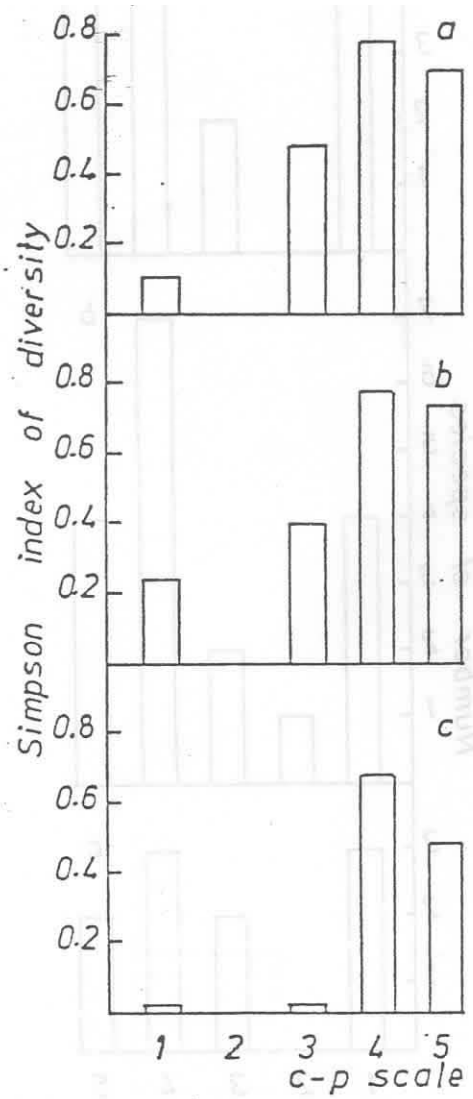


Fig. (3) Simpson index of diversity of total soil mesofauna at Wadi Quleib (a), Wadi Allaqi (b), and Dihmit farm (c) in relation to the colonizer-persister (c-p) scale.

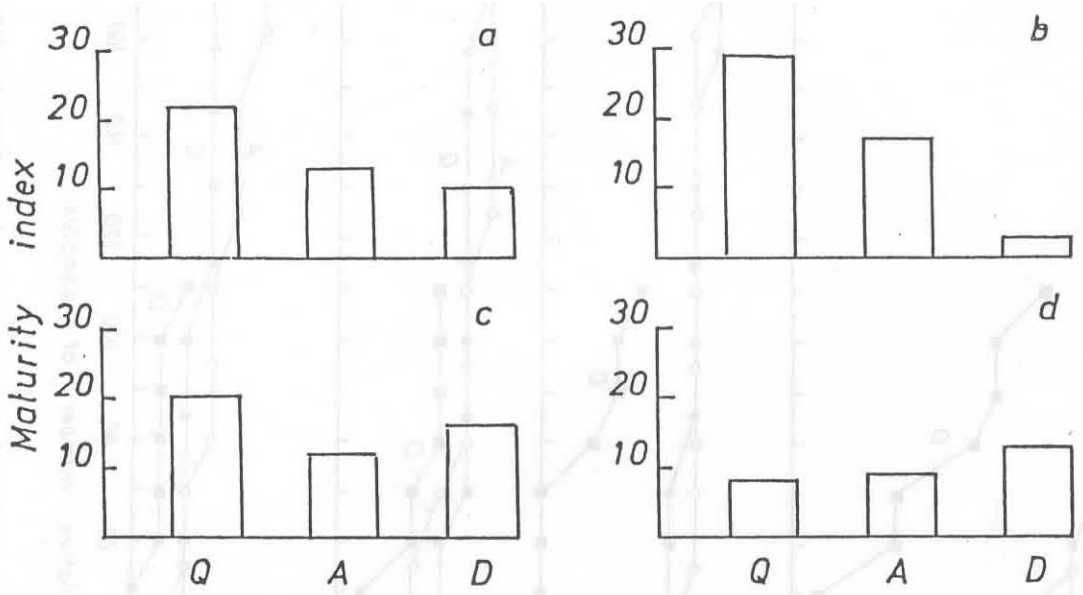


Fig. (4) Maturity index based on data of total soil mesofauna (a) detrivores (b), herbivores (c), and carnivores (d) collected in each of Wadi Quleib (Q), Wadi Allaqi (A), and Dihmit farm (D).

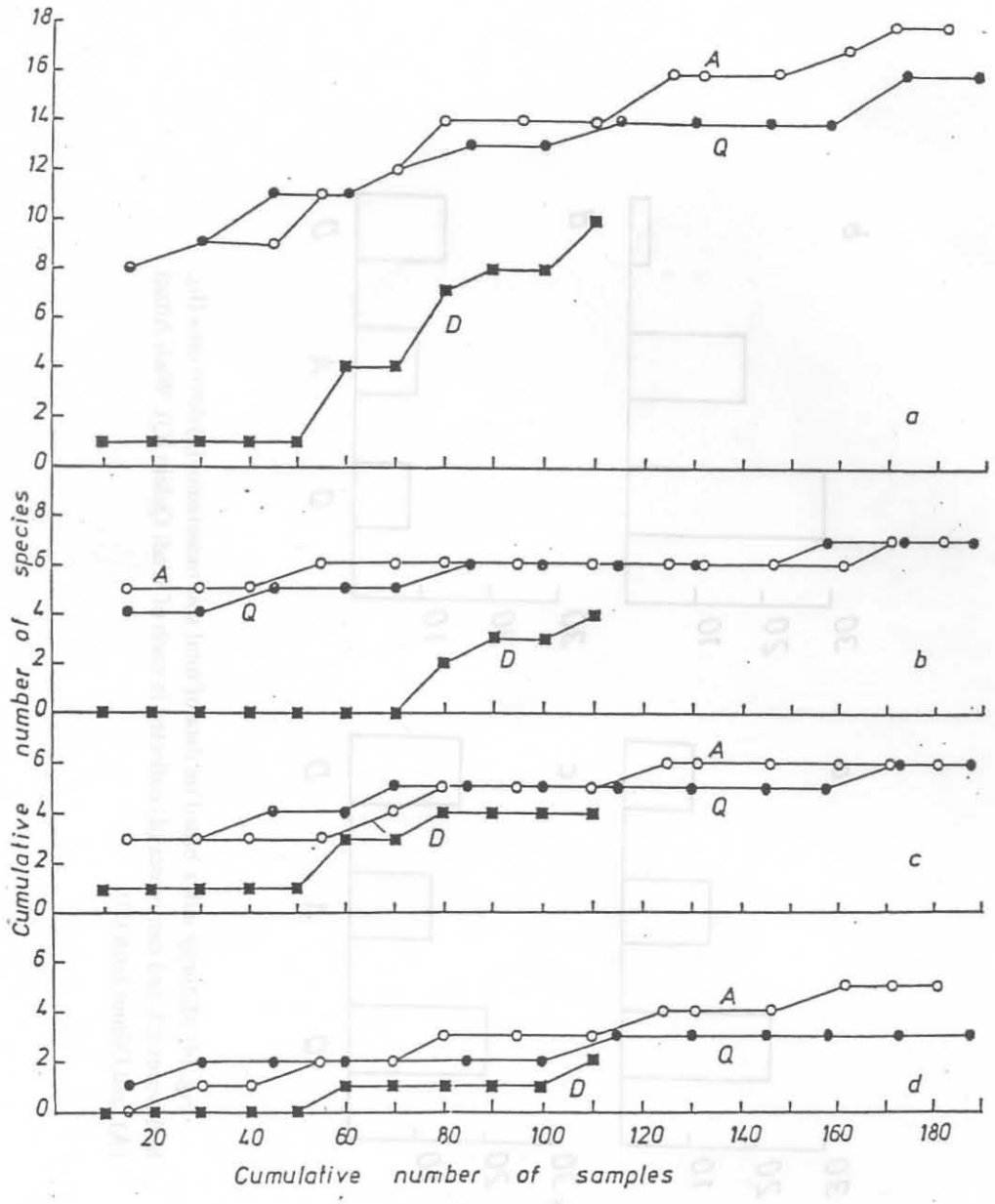


Fig. (5) Cumulative number of species of total soil mesofauna (a) detritivores (b), herbivores (c), and carnivores (d) collected in each of Wadi Quleib (Q), Wadi Allaqi (A), and Dihmit farm (D) in relation to the cumulative number of samples.

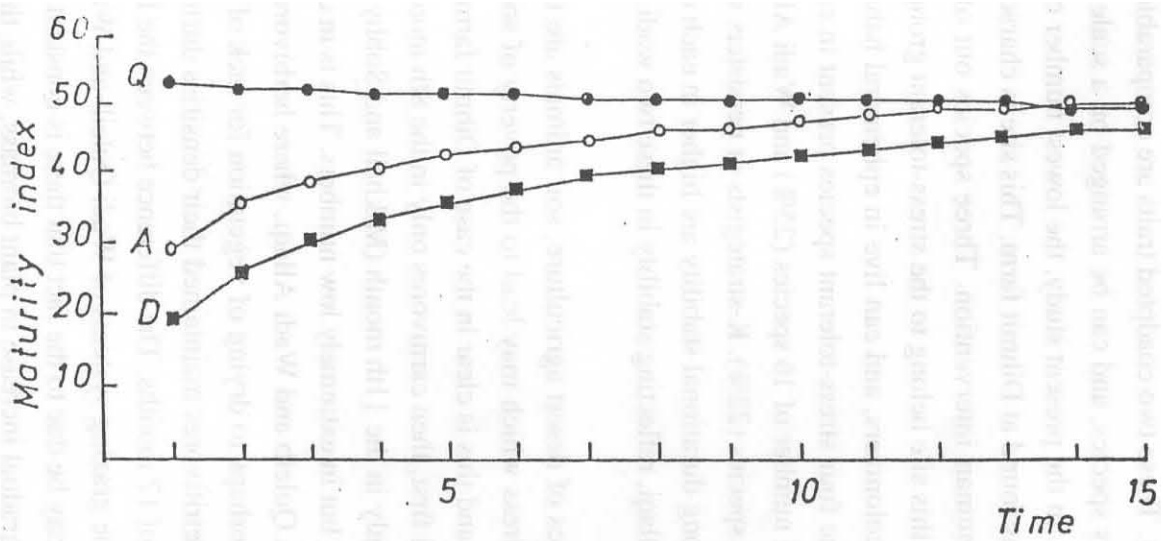


Fig. (6) Evolution of maturity index of soil mesofauna populations in each of Wadi Quleib (Q), Wadi Allaqi (A), and Dihmit farm (D).

DISCUSSION

Ways of explaining why certain "coadptive traits" are found together have been referred to as "r-selection" or "K-selection" (Wallwork 1980), or as a continuum of possibilities in-between such extremes (Crawford 1981). These two coadpted traits are comparable to colonizers and persisters species, and can be arranged on a scale from 1 to 5 (Bongers, 1990). In the present study, the lowest number of soil mesofauna species was found at Dihmit farm. This site is characterized by a high degree of human intervention. Three species out of 10 species (30%), found in this site belong to the stress-tolerant group, which are r- strategists or colonizers, and can live in ephemeral habitats. This is different from the four stress-tolerant species present in each of Wadi Quleib with total number of 16 species (25%) and Wadi Allaqi with total number of 18 species (22%). K-strategists or persisters which live in habitats with a long durational stability are higher in each of Wadi Quleib and Wadi Allaqi, reflecting stability in these two wadis, than in the case of Dihmit.

At early stages of desert agriculture, soil animals are under severe environmental stress which may lead to the poverty of soil taxa other then herbivores, and this is clear in the case of Dihmit farm, where herbivores appeared first, then carnivores only in the 8th month, followed by detritivores only in the 11th month (Mikhail and Sobhy 1992), after start of sampling but in extremely low numbers. This is in contrast with the case of Wadi Quleib and Wadi Allaqi, where herbivores decreased gradually (due perhaps to drying of vegetation for lack of rain), while carnivores and detritivores maintained their densities during the entire sampling period of 17 months. The difference between the Dihmit agroecosystem and the grazing systems of Wadi Quleib and Wadi Allaqi in this connection may be due to the fact that there is constant irrigation in the former with gradual increase in plant biomass, while the two desert ecosystems enjoyed only five sporadic rain events before sampling started and soil moisture gradually decreased as did the green plant biomass.

According to Margalef (1963), a more mature ecosystem can be equated with a more complex ecosystem; maturity is a quality that increases with time in any undisturbed ecosystem in a progressive and directional way. This will appear in the case of Wadi Quleib which is the most stable (less disturbed) ecosystem, followed by Wadi Allaqi (less stable), since the area of this Wadi was previously inundated by water of Lake Nasser and invaded by the *Tamarix* shrubs, has a number of human settlements, is exposed to more intensive grazing, and is the route of camel caravans from the Sudan to the Nile Valley, through to Cairo. On the other hand, Dihmit farm is the most disturbed. It is even made out from zero ecosystem conditions. This will suggest that irruption of potential agricultural pests is more probable with the reclamation of such desert areas to become agro-ecosystems end that they need continuous monitoring because they are still immature undergoing ecological succession and did not reach ecological equilibrium.

The concept of maturity index as developed for nematodes by Bongers (1990) can be used for the same nematodes species in all habitats since the composition and diversity of Nematoda populations do not change from one habitat to the other (Oteifa 1992). With soil mesofauna, whose populations change in structure and diversity from one habitat to another, the scale attributed to each species (colonizer to persister) has to be calculated anew for each species in each habitat, on the basis of its frequency of occurrence in samples collected from that particular habitat. Maturity index of the total soil mesofauna populations shows that Dihmit farm is still young and immature and Wadi Quleib is to be considered as a mature ecosystem, whereas Wadi. Allaqi is intermediate. Concerning the functional groups, only detritivores follow the same pattern while in the case of herbivores the order is Allaqi minimum (least mature) and Quleib maximum. In the case of carnivores Quleib is minimum and Dihmit is maximum, showing that carnivores (natural enemies of pests) are disfavoured with increasing disturbance. Use of maturity index is therefore recommended as a tool for understanding the intensity of disturbance in ecosystems of unknown history. Its use for

functional groups of soil mesofauna will further help to understand the status of natural enemies and to correct their dynamic imbalances in order to increase their efficiency. As the young ecosystem becomes more mature, the persister species will tend to replace colonizers during specific periods of time. As a result, higher values of maturity index are to be observed. On the other hand, if an ecosystem undergoes disturbance, persister species are to be replaced by colonizers and lower values of maturity index will obtain.The study of the evoluation of maturity index in relation with time for such ecosystem, provides us the status of that ecosystem and its future, whether it attains stability or undergoes deterioration.

Dunning *et al.* (1992) suggest that population dynamics are linked to landscape variation if interpreted through an ordered framework consisting of three elements: (a) the structural (compositional and physiognomic) feature of the landscape, (b) the habitat-specific responses of the organisms, and (c) the ecological processes that occur in this landscape. Generalizing the potential types of processes that can occur in landscape should assist in predicting how populations and communities will vary over large areas. Understanding these processes and interactions will help in predicting changes in population dynamics or community structure from a change in landscape structure. With increasing human modification of natural landscape, understanding these processes is of critical importance. Dunning *et al.* (1992) advocate experimental manipulation of landscape patches by changing their amounts, and watching changes in landscape physiognomy and composition in order to better asses the relative importance of different landscape features. Such an experimental approach is very much needed in future work concerning land reclamation in deserts, where original soil fauna communities adapted to desert conditions are transformed to communities more adapted to the new agroecosystems.

ACKNOWLEDGEMENTS

This research was carried out within the framework of the project "Sustainable Development of Wadi Allaqi" sponsored by the University of Assiut, Faculty of Science in Aswan, and funded by the United Nations Environmental Programme, and directed by Prof. A. Esmat Belal, Faculty of Science in Aswan (South Valley University). Sincerest thanks are due to these organizations and to the Director and staff of the project.

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